Ch.2 Light and Ether

Belief in an ether, why?

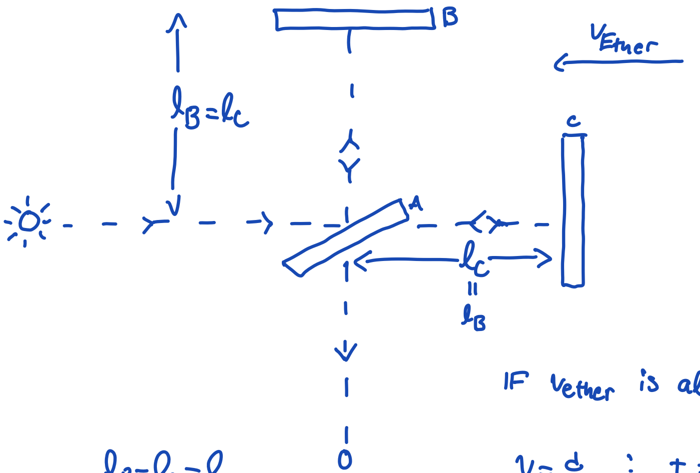
- Maxwells equations predict that light is an EM wave. whats waving?
- The maxwell equations predict that light propigates w/ a speed.

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = 3.0\times10^{8}\,m/s \qquad c \text{ is the speed of light}$$

The mickelson - morley experiment

In the rest frame of the interferometer

- Experiment was designed to meusure V_{ether}



$l_B = l_C = l$

If V_{ether} is along AC, then $t_{ACA} > t_{ABA}$

$v = \frac{d}{t} \;\therefore\; t = \frac{d}{v}$

So the light traveled speed relative to MM experiments.....

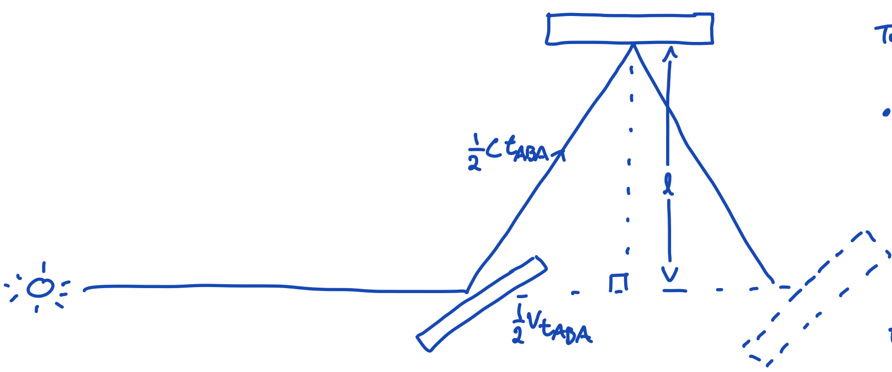
From A to C is $c-v$
From C to A is $c+v$ } By G.V.T

Total travel time A to C to A is

$$t_{ACA} = t_{AC} + t_{CA} = \frac{l}{c-v} + \frac{l}{c+v} = l\,\frac{c(c+v)+(c-v)}{(c-v)(c+v)} = \frac{2lc}{c^2-v^2}\cdot\frac{1/c^2}{1/c^2}$$

$$t_{ACA} = \frac{2l}{c}\cdot\frac{1}{(1-v^2/c^2)}$$

Consider light traveling from A to B to A, In the rest frame



Total Travel $= t_{BA} = t_{AB} + t_{BA} \;:\; t_{AB} = t_{BA} = \frac{1}{2}t_{ABA}$

- light travels at c W.R.T Ether

By the pythagorean theorem....

$$\left(\frac{1}{2}ct_{ABA}\right)^2 = l^2 + \left(\frac{1}{2}vt_{ABA}\right)^2$$

$$t_{ABA}^2\left(\frac{1}{4}c^2 - \frac{1}{4}v^2\right) = l^2 = \frac{1}{4}c^2\left(1-\frac{v^2}{c^2}\right)t_{ABA}^2$$

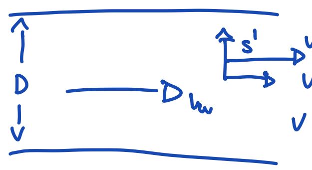
$$t_{ABA}^2 = \frac{4l^2}{c^2}\cdot\frac{1}{(1-v^2/c^2)} \;\therefore\; t_{ABA} = \frac{2l}{c}\,\frac{1}{\sqrt{1-v^2/c^2}}$$

In summ which is bigger?

$$t_{ACA} = \frac{2l}{c} \cdot \frac{1}{1 - v^2/c^2} \qquad \frac{t_{ACA}}{t_{ABA}} = \frac{1}{1 - v^2/c^2} \cdot \sqrt{1 - v^2/c^2} = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$t_{ABA} = \frac{2l}{c} \cdot \frac{1}{\sqrt{1 - v^2/c^2}} \qquad t_{ACA} = \frac{t_{ABA}}{\sqrt{1 - v^2/c^2}} \quad \therefore \ t_{ACA} > t_{ABA}$$

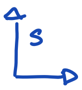
Ex:



$D = 120\ m$

$V = V_w = 1.0\ m/s$

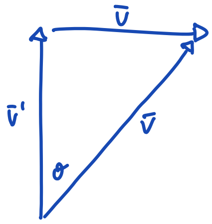
$v' = V_r = 2.0\ m/s$



$\therefore$ $\bar{v}$ relative to stationary shore

$\bar{v}'$ relative to water

a.)



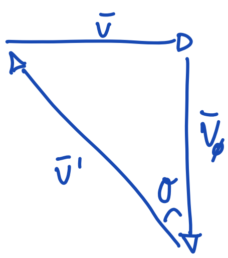
$$\bar{v}' = 2.0\ m/s = \frac{D}{t} = \frac{120\ m}{2.0\ m/s} = 60\ s$$

$$D = \bar{v}(t) = (1.0\ m/s)(60\ s) = 60\ m$$

$$\theta = \tan^{-1}\left(\frac{\bar{v}}{\bar{v}'}\right)$$

60m

b.)



$$\sin\theta = \frac{V}{V'} = \frac{1.0\ m/s}{2.0\ m/s}$$

$$\theta = 30^\circ$$

$$V = \sqrt{v'^2 - V_\phi^2}$$
$$= \sqrt{(2.0\ m/s)^2 - (1.0\ m/s)^2}$$
$$= \sqrt{3}\ m/s$$

$V = \sqrt{3}\ m/s$